UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
2443 WARRENVILLE RD. SUITE 210
LISLE, IL 60532-4352

May 18, 2022

EA-21-167
EN 54946
NMED Nos. 200416 and 220174 (Closed)

Dwayne Pinkney, Ph.D.
Executive Vice President for
Finance and Administration
Indiana University-IUPUI/IU Medical
Center Campus
1120 W. Michigan St.
Radiation Safety Room 159
Indianapolis, IN 46202-5111

SUBJECT: NRC REACTIVE INSPECTION REPORT NO. 030-01609/2020002(DNMS)
OFFICE OF INVESTIGATIONS REPORT NO. 3-2021-002
INDIANA UNIVERSITY-IUPUI/IU MEDICAL CENTER CAMPUS (IUPUI)

Dear Dr. Pinkney:

This letter refers to both a U.S. Nuclear Regulatory Commission (NRC) Region III reactive inspection and an investigation completed on November 10, 2021, by the NRC Office of Investigations (OI). The reactive inspection was conducted on October 19-20, 2020, at the Indiana University Methodist Hospital, with continued in-office review through April 14, 2022. The OI investigation took place at the site of Indiana University-IUPUI/IU Medical Center Campus (IUPUI) in Indianapolis, Indiana.

The purpose of the reactive inspection was to review the circumstances, root and contributing causes, and proposed corrective actions for a medical event that occurred on October 13, 2020. Your staff reported this medical event to the NRC on the same day (Event Notification (EN) 54946). The medical event involved an underdose to the treatment site from an administration of yttrium-90 (Y-90) microspheres. The in-office review included a review of your follow-up written report (dated October 26, 2020) and proposed corrective actions taken in response to the event. The event occurred due to a loss of flow within the microsphere administration system, because the authorized physician elected to use a catheter with a smaller inner diameter than specified in the manufacturer's package insert. The physician terminated the treatment after the unsuccessful attempt using the smaller catheter. Your staff returned the microsphere administration system to the device manufacturer for analysis. The manufacturer confirmed your staff's initial assessment of the cause of the medical event. No violations of NRC requirements were identified surrounding this medical event. The enclosed inspection report (Enclosure 1) presents the results of the inspection.

The OI investigation was conducted to determine whether willful failures to comply with NRC requirements occurred regarding (1) two interventional radiologists working for IUPUI who did not wear dosimetry assigned to them by IUPUI and (2) IUPUI requiring and monitoring the wearing of dosimetry. This investigation was initiated following the identification by the inspector that an interventional radiologist was not wearing required dosimetry during the use of Y-90. A factual summary of the investigation is provided as Enclosure 2.

The scope of the inspection to review the reported underexposure during the Y-90 treatment was expanded to include a review of the circumstances, root and contributing causes, and your proposed corrective actions related to two overexposures reported to the NRC in a letter dated April 23, 2021. You identified these overexposures following the identification by the inspector that the interventional radiologist (authorized user) conducting the follow-up treatment to the patient who received the underdose on October 13, 2020, was not wearing dosimetry. This interventional radiologist, who worked with both byproduct materials (licensed radiation sources) and x-ray generating devices (unlicensed radiation sources), received an annual radiation dose in 2012 and 2013 of 5.132 rem and 7.082 rem total effective dose equivalent respectively, which exceeded the NRC's annual occupational limit of 5 rem total effective dose equivalent. Your staff assessed these exposures by calculation because this individual failed to wear dosimetry while working with radioactive materials and machine-produced sources of radiation for several years. A second individual also failed to wear his assigned dosimetry for several years between 2016 and 2020. Your dose reconstruction concluded that the exposure for this second individual did not exceed the regulatory limits. A final exit meeting was held between Ms. Deborah A. Piskura of my staff and Dr. Michael Martin and members of your staff by videoconference on April 18, 2022, to discuss the inspection findings.

During this inspection, the NRC staff examined activities conducted under your license related to public health and safety. Additionally, the staff examined your compliance with the NRC's rules and regulations as well as the conditions of your license. Within these areas, the inspection consisted of a selected examination of procedures and representative records, observations of activities, and interviews with personnel.

Based on the results of the inspection and the information developed during the investigation, four apparent violations were identified and are being considered for escalated enforcement action in accordance with the NRC Enforcement Policy. The current Enforcement Policy is included on the NRC Web site at http://www.nrc.gov/about-nrc/regulatory/enforcement/enforce-pol.html. The apparent violations are not related to the medical event, but rather are related to the implementation of your personnel dosimetry (individual monitoring) program. The apparent violations involve the failures to: (1) control the annual occupational dose or total effective dose equivalent to an individual to 5 rem as required by Title 10 of the *Code of Federal Regulations* (CFR) 20.1201(a)(1)(i); (2) monitor exposure from licensed and unlicensed radiation sources as required by 10 CFR 20.1502(a); (3) implement certain elements of your radiation protection program as required by 10 CFR 20.1101(a); and (4) provide instruction to individuals who were likely to receive in a year, an occupational dose in excess of 100 millirem as required by 10 CFR 19.12(a)(3). In addition, the violation of 10 CFR 20.1502(a) appears to have been willful. Because the NRC has not made a final determination in this matter, the NRC is not issuing a Notice of Violation for these findings at this time. Ms. Piskura of my staff discussed the circumstances surrounding the apparent violations, the significance of the issues, and the need for lasting and effective corrective action with you and members of your staff on April 18, 2022.

Before the NRC makes its enforcement decision, we are providing you an opportunity to: (1) respond in writing to the apparent violations addressed in this inspection report within 30 days of

the date of this letter; (2) request a Predecisional Enforcement Conference (PEC); or (3) request alternative dispute resolution (ADR). If a PEC is held, the PEC will be closed to public observation since information related to an Office of Investigations report will be discussed and the report has not been made public. **Please contact Mr. Michael A. Kunowski, Chief, Materials Inspection Branch, at 630-829-9618 or by email at** Michael.Kunowski@nrc.gov, **within 10 days of the date of this letter to notify the NRC of your intent to respond in writing or participate in a PEC or pursue ADR**. A PEC should be held within 30 days and an ADR session within 45 days of the date of this letter.

If you choose to provide a written response, it should be clearly marked as "Response to the Apparent Violations in Inspection Report No. 030-01609/2020002(DNMS); EA-21-167," and should include, for the apparent violations: (1) the reason for the apparent violations, or, if contested, the basis for disputing the apparent violations; (2) the corrective steps that have been taken and the results achieved; (3) the corrective steps that will be taken to avoid further violations; and (4) the date when full compliance was or will be achieved. In presenting your corrective actions, you should be aware that the promptness and comprehensiveness of your actions will be considered in assessing any civil penalty for the apparent violations. The guidance in NRC Information Notice 96-28, "Suggested Guidance Relating to Development and Implementation of Corrective Action," may be useful in preparing your response. You can find the information notice on the NRC website at: http://www.nrc.gov/reading-rm/doc-collections/gen-comm/info-notices/1996/in96028.html. In addition, if you choose to provide a written response, to the extent possible, your response should not include any personal privacy, proprietary, or safeguards information. Your response may reference or include previously docketed correspondence if the correspondence adequately addresses the required response. Your response should be sent to the Director, Division of Nuclear Materials Safety, U.S. Nuclear Regulatory Commission, Region III, 2443 Warrenville Road, Suite 210, Lisle, IL 60532-4352 and emailed to RIIIEICS_ADMIN Resource@nrc.gov. If an adequate response is not received within the time specified or an extension of time has not been granted by the NRC, the NRC will proceed with its enforcement decision or schedule a PEC.

If you choose to request a PEC, it will afford you the opportunity to provide your perspective on the apparent violations and any other information that you believe the NRC should take into consideration before making an enforcement decision. The decision to hold a PEC does not mean that the NRC has determined that a violation has occurred or that enforcement action will be taken. This conference would be conducted to obtain information to assist the NRC in making an enforcement decision. The topics discussed during the conference may include the following: information to determine whether a violation occurred, information to determine the significance of a violation, information related to the identification of a violation, and information related to any corrective actions taken or planned to be taken.

In lieu of a PEC, you may also request Alternative Dispute Resolution (ADR) with the NRC in an attempt to resolve this issue. ADR is a general term encompassing various techniques for resolving conflicts using a neutral third party. The technique that the NRC has decided to employ is mediation. Mediation is a voluntary, informal process in which a trained neutral (the "mediator") works with parties to help them reach resolution. If the parties agree to use ADR, they select a mutually agreeable neutral mediator who has no stake in the outcome and no power to make decisions. Mediation gives parties an opportunity to discuss issues, clear up misunderstandings, be creative, find areas of agreement, and reach a final resolution of the issues. Additional information concerning the NRC's program can be obtained at http://www.nrc.gov/about-nrc/regulatory/enforcement/adr.html. The Institute on Conflict Resolution (ICR) at Cornell University has agreed to facilitate the NRC's program as a neutral

third party. Please contact ICR at 877-733-9415 within 10 days of the date of this letter if you are interested in pursuing resolution of this issue through ADR.

Please be advised that the number and characterization of the apparent violations described in the enclosed inspection report may change as a result of further NRC review. You will be advised by separate correspondence of the results of our deliberations on this matter.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter, its enclosures, and your response if you choose to provide one, will be made available electronically for public inspection in the NRC's Public Document Room or from the NRC's Agencywide Documents Access and Management System (ADAMS), accessible from the NRC's website at http://www.nrc.gov/reading-rm/adams.html. However, you should be aware that all final NRC documents, including the final Office of Investigations report, are official agency records and may be made available to the public under the Freedom of Information Act and subject to redaction of certain information in accordance with the Freedom of Information Act. To the extent possible, your response should not include any personal privacy or proprietary information so that it can be made available to the public without redaction.

Please feel free to contact Ms. Piskura of my staff if you have any questions regarding this inspection. Ms. Piskura can be reached at 630-829-9867.

Sincerely,

Kathryn M. Brock Signed by Brock, Kathryn on 05/18/22

Kathryn Brock, Acting Director
Division of Nuclear Materials Safety

Docket No. 030-01609
License No. 13-02752-03

Enclosures:
1. Inspection Report No. 030-01609/2020002 (DNMS)
2. Factual Summary of Office of Investigations Report Number 3-2021-002

cc (w/encl): Michael Martin, Ph.D.,
Radiation Safety Officer
Kathryn Manteuffel, IUPUI
Benjamin Hunter, IUPUI
State of Indiana

Letter to D. Pinkney from K. Brock dated May 18, 2022.

SUBJECT: NRC REACTIVE INSPECTION REPORT NO. 030-01609/2020002(DNMS)
OFFICE OF INVESTIGATIONS REPORT NO. 3-2021-002
INDIANA UNIVERSITY-IUPUI/IU MEDICAL CENTER CAMPUS (IUPUI)

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DATE	4/25/2022		4/26/2022		4/27/2022		5/17/2022	
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U.S. Nuclear Regulatory Commission
Region III

Docket No.	030-01609
License No.	13-02752-03
Report No.	030-01609/2020002(DNMS)
NMED Nos.	200416 and 220174
Licensee:	Indiana University-IUPUI/IU Medical Center Campus (IUPUI)
Address:	1120 W. Michigan St. Indianapolis, IN 46202-5111
Location Inspected:	IU Health Methodist Hospital campus I-65 and 21st Street Indianapolis, Indiana
Inspection Dates:	October 19-20, 2020, with continued in-office review through April 14, 2022
Exit Meeting Date:	April 18, 2022
Inspector:	Deborah A. Piskura, Senior Health Physicist
Approved By:	Michael A. Kunowski, Chief Materials Inspection Branch Division of Nuclear Materials Safety

EXECUTIVE SUMMARY

Indiana University-IUPUI/IU Medical Center Campus (IUPUI)
NRC Inspection Report 030-01609/2020002(DNMS)

The U.S. Nuclear Regulatory Commission (NRC) conducted a reactive inspection on October 19-20, 2020, to review a medical event that occurred and was reported to the NRC on October 13, 2020, at the IU Methodist Hospital, a location of use for the Indiana University-IUPUI/IU Medical Center Campus (IUPUI, the licensee). The medical event involved an underdose by approximately 46 percent to one of three prescribed treatment sites utilizing yttrium-90 (Y-90) microspheres in the BTK TheraSphere® administration system. The inspection included in-office review through April 14, 2022, of the results of the device manufacturer's analysis of the returned TheraSphere® administration device and the licensee's dose reconstruction data spanning several years for two interventional radiologists.

The cause of the medical event was attributed to the use of a catheter of smaller diameter than normally used; the preferred sized catheter was not available at the time of the treatment. During the start of the treatment, the authorized user noted that the microspheres were collecting at the inlet, preventing adequate flow through the catheter; he then terminated the treatment. The licensee concluded that the medical event would not result in adverse health consequences for the patient. The manufacturer of the microsphere delivery system subsequently concluded that the use of the smaller diameter catheter prevented adequate pressure within the system to allow the proper flow of microspheres to the patient.

On October 20, 2020, the inspector was onsite at the facility to observe administration of the compensating treatment of microspheres to the patient and to review the event of October 13. The inspector identified that one interventional radiology physician, authorized as a user for Y-90 administrations and who had conducted the treatments on October 13 and 20, had not routinely worn his assigned personnel dosimeters, which are intended to be used to monitor radiation dose to the individual. At the NRC's request, the licensee performed a retrospective evaluation of the radiation dose received by this physician. The licensee also evaluated the dose received by a second physician who the licensee identified as likely not wearing his dosimetry as required during Y-90 treatments. The licensee's evaluation concluded that the first physician had received exposures in excess of NRC's regulatory limit for 2012 and 2013; no overexposures were identified for the second physician.

Four apparent violations of NRC requirements were identified during this inspection. The apparent violations involved the licensee's failures to: (1) control the annual occupational dose or total effective dose equivalent to an individual to 5 rem as required by Title 10 of the Code of Federal Regulations (CFR) 20.1201(a)(1)(i); (2) monitor exposure from licensed and unlicensed radiation sources as required by 10 CFR 20.1502; (3) implement certain elements of the radiation protection program as required by 10 CFR 20.1101(a); and (4) provide instruction to individuals who were likely to receive in a year, an occupational dose in excess of 100 millirem as required by 10 CFR 19.12(a)(3).

The root cause of the failures associated with the licensee's personnel monitoring program can be attributed to the deliberate failure of two interventional radiologists to wear their dosimetry; the failure of the Radiation Safety Office and the Radiation Safety Committee to provide adequate oversight of the licensee's Radiation Safety Program; and the failure to take corrective actions to address identified deficiencies in the personnel monitoring program.

Following the onsite inspection, the licensee implemented several corrective actions to address the personnel dosimetry issue, which included revising licensee policies monitoring use of dosimetry, and providing individuals with instruction regarding the licensee's policies on the use of personnel monitoring devices.

REPORT DETAILS

1 Program Overview and Inspection History

The Indiana University-IUPUI/IU Medical Center Campus (licensee) was a large medical institution that conducted licensed activities at six locations in the Indianapolis area. Under License Number 13-02752-03, the licensee operated a Type A medical broad scope program with authorization to use licensed material with atomic numbers 3-83 and yttrium-90 (Y-90) microspheres. The licensee administered Y-90 microsphere treatments utilizing the BTG International Canada, Inc. TheraSphere® Administration Set at its University Hospital and IU Methodist Hospital. The Food and Drug Administration granted the manufacturer of TheraSphere® a Humanitarian Device Exemption, allowing the use of new technologies that otherwise would not be available through more conventional processes to encourage research and development of treatments for rare diseases. The device exemption of TheraSphere® was limited to the treatment of unresectable liver cancer. The licensee established a Radiation Safety Committee to review and approve users, uses, and facilities as required for a medical broad scope licensee. All human research protocols, including the use of TheraSphere®, were reviewed by the licensee's Institutional Review Board. The licensee's daily radiation safety activities were managed by the licensee's Radiation Safety Office, comprising a dedicated, full-time radiation safety officer (RSO), three staff health physicists (functioning as Assistant RSOs), one student health physics technician, and one office assistant.

The nuclear medicine department at the IU Methodist Hospital administered approximately 150-200 Y-90 microsphere treatments annually using the TheraSphere® brand microspheres. The licensee's Radiation Safety Committee approved eight interventional radiologists (IRs) as authorized users for Y-90 microspheres. These IRs also used radiation-producing devices, such as fluoroscopes and other x-ray generating devices, that are not licensed or regulated by the NRC. The licensee developed protocols for the administration of TheraSpheres®, based on patient anatomy, vasculature, tumor volume, and liver volume. The licensee instituted a multi-departmental approach for the use of Y-90 microspheres. The team consisted of an IR/authorized user, a nurse, a nuclear medicine technologist, a radiology technician, and a health physicist from the radiation safety office. The licensee received unit doses of the Y-90 microspheres from the vendor from which it assayed and stored the prepared dosages within the nuclear medicine hot lab. The team administered all microspheres treatments within the interventional radiology suite. Following the TheraSphere® treatment, the licensee imaged the patient to verify that the treatment was performed in accordance with the written directive.

The NRC conducted annual routine inspections on June 3-7, 2019, and May 21-25, 2018, as part of the Regional Office's "broad scope initiative;" with no violations of NRC requirements identified during these inspections. The NRC conducted a reactive inspection on September 27 and 28, 2018, to review a medical event that occurred on August 31, 2018. The medical event involved an underdose from a treatment with Y-90 microspheres in a BTG International Canada, Inc. TheraSphere® Administration Set. No violations of NRC requirements were identified during the review of this medical event.

2 Sequence of Events and Licensee Investigation

2.1 Inspection Scope

The inspector reviewed the licensee's investigation of the medical event. The inspector also interviewed selected licensee personnel, reviewed the licensee's written policies and procedures for Y-90 administrations, and observed equipment and facilities. The inspector observed the licensee staff prepare, assay, and administer a compensating dosage of microspheres to the patient on October 20, 2020.

2.2 Observations and Findings

On the morning of October 13, 2020, the nuclear medicine and interventional radiology personnel prepared, assayed, and assembled the TheraSphere® delivery system and initiated a patient treatment for unresectable cancer to five segments within the right lobe of the liver. Based on the patient's anatomy and the blood flow to the tumor, the authorizer user prescribed a dosage of 28.6 millicuries to segments 6 and 7a; 56.8 millicuries to segments 6 and 7b; and 46.7 millicuries to segments 5 and 8 of the patient's liver. The authorized user prescribed a total dose of 120 gray (equivalent to 120 Sievert or 12,000 rem) to segments 5 and 8.

The licensee staff transported the dosages, the Administration Set, and the Administration Accessory Kit to the interventional radiology suite. The IR administered the prescribed dosages to Segments 6 and 7a and Segments 6 and 7b in accordance with the respective written directives. The IR prepared to treat segments 5 and 8 with the intent of using a 2.4 French high flow microcatheter with an inner diameter of 0.020 inches; the IR requested the staff to prepare the dosage and locate a 2.4 French catheter within the interventional suite storage cabinet. The radiology technicians searched the storage cabinets to locate the microcatheter size requested by the IR. These searches did not locate the 2.4 French microcatheter. The staff informed the IR of its attempts to locate the desired catheter, offering an alternative 2.0 French catheter with an inner diameter of 0.019 inches. Note that according to the manufacturer's package insert, a catheter with an inner diameter of greater than or equal to 0.020 inches was required to maintain sufficient flow within the Administration Set to avoid any possible occlusions or retention of microspheres within the line. The package insert provided a user warning that the use of a smaller diameter catheter may cause microspheres to be retained in the Administration Set and within the catheter which could result in a misadministration (now referred to a medical event).

After the licensee staff positioned the Administration Set within the Administration Accessory Kit, the IR initiated the treatment. The IR used the 2.0 French microcatheter, noting that there may be difficulties with the administration where the microspheres could fall out of suspension within the catheter. While the IR's use of a 2.0 French (inner diameter of 0.019 inches) catheter was not within the general guidelines or instructions in the package insert, his medical judgement permitted him to administer this third treatment, using this size of catheter.

In preparation for the treatment, the IR primed the system to purge air within the tubing. The IR verified the positioning of the microcatheter within the treatment site using contrast media under angiography. This action also verified the flow through the microcatheter to the patient to ensure that the microspheres had an unobstructed path to

the patient. At the start of the administration of the dosage, the IR noted difficulty keeping the spheres in flow through the microcatheter with a large amount of the spheres collecting at the outlet needles and remaining within the treatment v-vial (the v-shaped vial that holds the microspheres). The ambient radiation levels near the Administration Set remained greater than 100 milliroengtens per hour, confirming that the spheres were not administered into the patient. The staff surveyed near the dose vial within the Administration Accessory Kit and noted that the readings were high, indicating that a significant amount of the dosage remained in the v-vial. A visual examination of the v-vial confirmed that a significant amount of microspheres remained in the v-vial. The staff cut the tubing marked "B" separating the "cold" portion from the "hot" portion of the Administration Set and placed the hot portion including the dose vial into a waste container. The waste container was secured within the hot lab.

Based on the licensee's calculations, the patient received a dosage of approximately 25.2 millicuries of Y-90 microspheres or 54 percent of the prescribed dosage to segments 5 and 8 of the liver; approximately 46 percent of the dosage remained in the v-vial and tubing of the Administration Set. The administered dosage differed from the prescribed dosage by 20 percent. The dose to segments 5 and 8 of the liver differed by more than 55 Gray or 55 Sievert (equivalent to 5,500 rem) from the prescribed dose. Therefore, the administration fit the criteria as a medical event reportable to the NRC in accordance with 10 CFR 35.3045.

The licensee's initial investigation attributed the cause of the medical event to the use of a catheter with dimensions outside of the manufacturer's recommended use listed in the package insert. The radiation safety staff discussed this incident with representatives of the device manufacturer. The licensee held the "hot" portion of the Administration Set for decay prior to shipping the system to the device manufacturer for analysis. The manufacturer confirmed receipt of this system on November 19, 2020.

The licensee concluded that the medical event would not result in adverse health consequences for the patient. On October 20, 2020, the licensee (including the same IR from the October 13 event) administered a compensating dosage to the patient, which the inspector observed; the dose was administered in accordance with the written directive.

2.3 Conclusions

The licensee reported the October 13, 2020, medical event to the NRC on the same day as the treatment because the event involved an underdose to the treatment site that differed from the prescribed dose by 50 rem to an organ or tissue, and the total dose differed by greater than 20 percent from the prescribed dose. The licensee delivered only 54 percent of the prescribed dose to the patient. At the time of the licensee's initial reporting, the cause of the underdose was attributed to the use of a microcatheter with dimensions outside the specifications in the manufacturer's insert. The licensee sent the Administration Kit used for this patient treatment to the device manufacturer for analysis.

3 Device Manufacturer's Analysis

3.1 Inspection Scope

The inspector reviewed the licensee's investigation of the medical event. The inspector also interviewed selected representatives of the device manufacturer and reviewed information from the manufacturer provided to the licensee.

3.2 Observations and Findings

The device manufacturer, BTG International Canada, Inc., initiated its investigation of the licensee's returned Administration Set on November 24, 2020. The manufacturer's investigation included a visual inspection, radiation exposure rate surveys, digital microscopy, and pressure/flow testing. The manufacturer confirmed through visual inspection and surveys that residual microspheres remained within the dose vial, the Administration Set outlet tubing, and within the microcatheter up to the Tuohy Borst adaptor. The use of a smaller diameter microcatheter created conditions of a low flow rate of microspheres within catheter and a high backpressure. These conditions caused increased resistance to the administration of the microspheres within the tubing at the outlet needles preventing the microspheres remaining in suspension to be delivered to the patient during the treatment. The manufacturer noted residual microspheres along the flow path, from the outlet tubing to the microcatheter which indicated inadequate pressure within the system to maintain the spheres in suspension. No defective components were identified by the device manufacturer in its analysis. The manufacturer advised the licensee to limit its use of catheters to those with dimensions within the specifications referenced in the TheraSpheres® package insert.

3.3 Conclusions

Based on the components that were returned, the manufacturer indicated that the cause of the medical event was due to the use of a catheter with an inner diameter outside of the minimum specifications listed in the package insert. The licensee's use of a smaller diameter catheter created conditions within the treatment catheter that prevented the microspheres from remaining in suspension and flowing through the catheter for infusion into the patient.

4 Licensee Corrective Actions for the Medical Event

4.1 Inspection Scope

The inspection included an assessment of the licensee's proposed corrective actions to prevent similar events. The inspector reviewed the licensee's October 26, 2020, written report of the medical event and interviewed the RSO, selected radiation safety and radiology staff, and the IR.

4.2 Observations and Findings

At the time of the administration, the radiology staff were unable to locate the specific microcatheter size requested by the physician for treatment of segments 5 and 8. The licensee's investigation determined that the manner in which the microcatheters were organized within the storage cabinet delayed the staff in their search for the specific size

requested by the authorized user. After failed attempts to locate the specific size of microcatheter to meet the referring physician's orders, the IR decided to use the next sized catheter, offered by the radiology staff, to administer the third patient dosage.

As corrective actions, the licensee reviewed the conditions of use for the TheraSphere® brachytherapy system with all of the Y-90 authorized users (IRs) with emphasis on the microcatheter size limitations. The licensee also reviewed the radiology department's practice and organization of its microcatheters within the cabinets of the interventional suite. The licensee found that the microcatheters were not organized in a logical order, according to size, as the standard practice for interventional radiology.

4.3 Conclusions

The licensee implemented immediate corrective actions to address the direct cause of the medical event to preclude similar events. The root cause of this medical event was attributed to the IR's decision to use a microcatheter that was smaller than the minimum dimensions specified in the manufacturer's package insert to administer the microspheres.

5 Personnel Monitoring Program for Interventional Radiologists

5.1 Inspection Scope

While onsite on October 20, 2020, to review the medical event of October 13, the inspector observed that the IR administering the compensatory dose of Y-90 to the patient was not wearing the proper dosimetry. This inspection to review the medical event was then expanded to include a review of the licensee's dosimetry program with focus on all of the IRs authorized to use Y-90. The inspector reviewed records, procedures, and documents maintained by the licensee, observed licensed activities, and interviewed selected licensee personnel. The inspector reviewed information provided by the licensee following the onsite inspection, including its written notification of an overexposure for one IR for the calendar years 2012 and 2013.

5.2 Observations and Findings

The inspector identified that the IR (IR1) associated with the Y-90 treatments on October 13 and 20, 2020, failed to wear his assigned personnel monitoring (a whole body/collar badge and an extremity ring badge). The IR1 worked with Y-90 administrations (licensed sources) and x-ray or fluoroscopy procedures (unlicensed activities) at the licensee's IU Health Methodist Hospital since September 2012. This individual also worked with fluoroscopy at two other sites within the licensee's healthcare system. The inspector's review of dosimetry reports from 2012 to the year-to-date 2020 period indicated that the individual was apparently not properly wearing his assigned dosimeters. The inspector noted that the exposures were reported out as "minimal" meaning that the badge received no exposure to radiation. Other badge entries indicated that the badge was not returned to the dosimetry vendor by the user or the licensee for processing. During the inspection, IR1 informed the inspector that he did not wear his dosimetry.

At the conclusion of the onsite inspection, the inspector requested the licensee to conduct a dose assessment of IR1. The licensee committed to include available

fluoroscopy machine data for the years evaluated and empirical data from a replicate and representative procedural case. The licensee management committed to review and discuss this individual's failure to wear his assigned dosimetry during the next Radiation Safety Committee and Institutional Review Board meetings. The licensee committed to monitor the individual's compliance with wearing his dosimetry during Y-90 procedures while radiation safety staff are present who can verify this IR's compliance to wear his dosimetry.

Following the on-site inspection, the licensee reassessed the dosimetry data for all its authorized users of Y-90. The licensee identified several occasions between 2016 and 2018 where another IR (IR2) either failed to wear his assigned dosimetry (based on numerous readings as "M" for minimal) or failed to provide his dosimetry to the department coordinator for return to the vendor for processing (also indicated as "unread" by the vendor). The licensee's investigation concluded that IR2 had failed to wear his assigned dosimetry. When the RSO compared the exposure data reported out by the dosimetry provider with the Y-90 workload of IR2, the RSO informed the inspector that this exposure data for IR2 may be an underestimate due to IR2's apparent failure to consistently wear his assigned dosimetry.

Title 10 CFR 20.1502(a) requires, in part, that each licensee monitor exposure to radiation and radioactive material at levels sufficient to demonstrate compliance with the occupational dose limits of 10 CFR Part 20. At a minimum, each licensee shall monitor exposure to radiation from licensed and unlicensed radiation sources under the control of the licensee and shall supply and require the use of individual monitoring devices by adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in 10 CFR 20.1201(a).

The licensee's failure to monitor occupational exposure of IR1 and IR2 to radiation and radioactive material is an apparent violation of 10 CFR 20.1502(a). These missing and/or inaccurate dosimeter results went unrecognized by the licensee during its normal monthly dosimetry results reviews and its ALARA program reviews. Although a member of the radiation safety office assisted in all Y-90 administrations, the licensee failed to identify that these two IRs were not apparently wearing their assigned dosimetry during these procedures.

To make radiation dose assessment for the two IRs, the licensee gathered readily retrievable fluoroscopy time information related to procedures between the years 2012 to 2020 for IR1 and 2016 to 2020 for IR2. The licensee interviewed the IRs to gather information regarding the standard setup for various interventional radiology procedures, the use of various fluoroscopy modes, and the typical position of the IRs relative to the radiation beam during procedures. Based on the information collected, the licensee utilized a representative fluoroscopy unit in a standard interventional radiology procedure room to obtain representative radiation measurements. The licensee replicated a patient procedure using a water phantom. The radiation beam was collimated to a field size that was representative of the average field size used for interventional radiology procedures. The licensee then collected multiple radiation measurements at representative distances using both "Normal/Standard" and "Cine" fluoroscopy modes. Note that Cine mode produced a significantly higher radiation exposure rate than Normal mode. Radiation measurements were taken by the licensee with a calibrated ion chamber survey meter from behind a shield that provided 0.5 millimeters of lead attenuation.

The licensee used the following assumptions in making its radiation dose assessment for the two IRs. The licensee assumed that: (1) the IR was in the procedure room during every Cine run, although IRs normally leave the procedure room during Cine runs; (2) every interventional radiology procedure had a Cine mode component which accounted for 10 percent of the total procedure exposure, although not all procedures have a Cine mode component; and (3) the remaining 90 percent of the procedure exposure was attributed to Normal mode. The licensee's assumptions were conservative and provided reasonable values that did not appear to underestimate the radiation dose for each IR.

The licensee provided its initial radiation dose evaluation to the NRC on December 11, 2020 (ADAMS Accession No. ML21120A190). The NRC reviewed the licensee's evaluation and provided several follow-up questions to the licensee for additional clarification. On April 22, 2021, the licensee responded to the follow-up questions and provided a revised radiation dose evaluation for the two affected IRs (ADAMS Accession No. ML21120A198). Based on the licensee's revised calculations, IR1 exceed the occupational exposure limits of 5 rem total effective dose equivalent (TEDE) for 2012 and 2013. The licensee estimated that IR1 received 5.132 rem for 2012 and 7.082 rem for 2013.

Title 10 CFR 20.1201(a)(1)(i) requires, with exceptions not applicable here, that the licensee control the occupational dose to individual adults to an annual limit of 5 rem TEDE. The licensee's failure to control the occupational dose to the interventional radiologist to 5 rem TEDE is an apparent violation of 10 CFR 20.1201(a)(1)(i).

The root cause of these overexposures was attributed to the IRs' deliberate failure to wear their assigned dosimetry. As dosimeters were exchanged monthly, trends towards overexposures would normally be identified prior to reaching limits. The IRs' failures to consistently wear their assigned dosimetry prevented the licensee from effectively monitoring trends in their exposures and to intervene, if necessary, should the IR approach the regulatory limits.

The RSO discussed the importance of wearing dosimetry during a presentation to the Hospital System-wide Radiology Leadership Council on December 3, 2020. This presentation emphasized the importance of proper dosimeter wear and informed the attendees on verification practices to be used by the radiation safety office during future Y-90 procedures to ensure that personnel monitoring is used by all interventional radiologists prior to Y-90 administrations.

The inspector evaluated the licensee's radiation dose estimates and determined that the licensee's approach and assumptions were technically sound. The licensee's methodology described in its dose reconstruction efforts did not appear to underestimate the radiation dose and resulted in conservative but reasonable radiation dose estimates for the two IRs.

The licensee implemented measures to restore compliance by revising its institutional ALARA program. Previously, the licensee's ALARA program only reviewed exposures above certain thresholds. The licensee revised its program to review unreturned/unused dosimeters, especially in groups where significant exposure was expected. The licensee implemented an annual compliance acknowledgement for IRs with instructions on the proper dosimetry wear-and-return procedures and informed the signed individual on the consequences for non-compliance if dosimetry was not worn. The licensee's previous

practices for evaluating personnel monitoring results were effective in identifying high or unusual dosimeter readings but were not effective in identifying a lack of dosimeter use (i.e., unused dosimeters or “M” readings) or unexpectedly low dosimeter readings.

Title 10 CFR 20.1101(a) requires, in part, that each licensee implement a radiation protection program commensurate with the scope and extent of licensed activities sufficient to ensure compliance with 10 CFR Part 20.

The licensee’s Policy, “Radiation Safety: Personnel Monitoring,” effective date August 29, 2019, Section E., Maximum Permissible Radiation Dose Limits for Individuals, Item III, The ALARA Program, SubItem A. states, in part, except when deemed necessary, no further action will be taken in those cases where an individual’s exposure is less than those listed under Level I. The licensee’s policy listed ALARA investigation levels as Level I and Level II.

The licensee’s failure to implement a radiation protection program commensurate with the scope and extent of licensed activities is an apparent violation of 10 CFR 20.1101(a).

The inspector identified that the licensee failed to provide adequate instructions regarding the proper use of personnel dosimeters to, at least, the two IRs who were likely to receive in a year an occupational dose in excess of 100 mrem. Both IRs stated that they had been previously instructed in medical school or during clinical assignments that dosimetry needed to be worn. These two IRs deliberately failed to properly wear their assigned dosimetry for a period of years. This failure to wear dosimetry directly impacted the licensee’s ability to effectively monitor and control the individuals’ occupational exposure to licensed and unlicensed sources of radiation. Consequently, one IR’s failure to wear dosimetry resulted in occupational exposures for two years in excess of the NRC limits.

Title 10 CFR 19.12(a)(3) requires, in part, that all individuals who in the course of employment are likely to receive in a year an occupational dose in excess of 100 mrem be instructed in, and required to observe, to the extent within the worker’s control, the applicable provisions of the NRC’s regulations and licenses for the protection of personnel from exposure to radiation and/or radioactive material.

The licensee’s failure to provide instruction to the two IRs, who in the course of their employment were likely to receive in a year an occupational dose in excess of 100 mrem, on the applicable provisions of the NRC’s regulations and licenses for the protection of personnel from exposure to radiation and/or radioactive material is an apparent violation of 10 CFR 19.12(a)(3).

The licensee implemented the following measures to restore compliance: (1) training to the IRs regarding the licensee’s policies and NRC regulations for personnel monitoring; (2) ensuring that the IRs received annual training on the Radiation Safety and Education module that is part of the licensee’s Institutional Review Board approval for TheraSpheres®, which emphasized the requirements for radiation monitoring and employee responsibilities; (3) revising the monthly assessment conducted by the radiation safety office of the dosimetry results of all Y-90 IRs and providing status reports to the Radiation Safety Committee for evaluation whether these exposures were appropriate for the workload during the respective monitoring period; and (4) obtaining

signed “Annual Statement of Compliance for IUH Users of TheraSpheres” sheets from each IR user of Y-90.

6.3 Conclusions

The inspector identified four apparent violations involving the licensee’s failures to: (1) control the occupational dose of individual adult to an annual dose limit of 5 rem TEDE; (2) monitor two individuals’ occupational exposure to radiation and radioactive material; (3) implement a radiation protection program commensurate with the scope and extent of licensed activities; and (4) provide instruction to occupationally exposed individuals. The licensee implemented corrective actions for these apparent violations.

7 Notifications and Reports

7.1 Inspection Scope

The inspector reviewed the licensee's notifications to the NRC Operations Center, the referring physician, and the patient. The inspector reviewed the licensee’s written report describing the medical event and the written report describing the overexposure for 2012 and 2013 to IR1.

7.2 Observations and Findings

On October 13, 2020, the day of the microspheres administration, the licensee notified the NRC Operations Center of the medical event (Event Notification 54946). The licensee notified the patient and the patient's referring physician. In addition, the licensee provided the IR and the referring physician a copy to its written report on the medical event. The licensee provided its written report of the medical event to the NRC in a letter dated October 26, 2020 (ADAMS Accession No. ML21120A201), detailing its initial actions taken in response to the medical event. In a letter dated, December 11, 2020, the licensee provided an addendum to its initial written report to include the device manufacturer’s analysis of the returned administration set. The report and the addendum included the information required by 10 CFR 35.3045(d)(1).

On April 22, 2021, the RSO notified Region III of the overexposures calculated for IR1. The RSO determined that IR1 exceeded 5 rem TEDE for 2012 and 2013. On April 23, 2021 (ADAMS Accession No. ML21126A217), the licensee provided a written report of these overexposures, in accordance with 10 CFR 20.2203(a). The report included all the information required by 10 CFR 20.2203(b).

7.3 Conclusions

The licensee made all the notifications and reports for the medical event as required by 10 CFR 35.3045 within the specified time period. The licensee’s written report for the medical event included all the required information. The licensee provided the written report for the overexposures as required by 10 CFR 20.2203. The report for the overexposures included the required information.

8 Other Areas Inspected

8.1 Inspection Scope

The inspector reviewed other aspects of the licensee's radiation protection program, which included security of licensed material, personnel monitoring, training, labeling of containers, and postings. The inspector observed licensee personnel prepare, assay, and administer a Y-90 microsphere dosage for a patient treatment. The inspector interviewed selected individuals, toured the licensee's facilities, examined the licensee's containers, and reviewed selected records. The inspector observed licensee personnel survey and decontaminate a small Y-90 spill within the interventional suite.

8.2 Observations and Findings

The inspector reviewed selected Radiation Safety Committee meeting minutes and documentation of training for physicians approved as authorized users of Y-90 microspheres. The Radiation Safety Committee established a quorum for its meetings held at least quarterly to review events, program audit results, and approve uses, facilities, and users. Audits of the radiation safety program, protocols for use of Y-90 microspheres and the review of these protocols through the licensee's Institutional Review Board were discussed in the meeting minutes. The licensee approved eight IRs as authorized users of Y-90 microspheres and documented the training and experience for their approvals. At the conclusion of the Y-90 administration observed by the NRC inspector on October 20, 2020, a small contamination incident occurred within the interventional suite. The licensee staff promptly identified, contained, and cleaned the contamination on the floor. The licensee cleaned the contamination to levels indistinguishable from background. All materials used for the decontamination efforts were placed in storage for decay.

8.3 Conclusions

Based on record reviews, interviews with personnel, and the observations described above, the inspector determined that no violations of NRC requirements were identified.

9 Exit Meeting Summary

The NRC inspector presented the preliminary inspection findings following the onsite inspection on October 20, 2020. The licensee did not identify any documents or processes reviewed by the inspector as proprietary. The licensee acknowledged the findings presented. The final exit meeting was conducted via videoconference on April 18, 2022.

LIST OF PERSONNEL CONTACTED

Vasantha Aaron, M.D., Medical Center Radiology Geochief
#*Steve Adams, Sr. Director, Public Safety
*Emily Choi, Assistant Radiation Safety Officer
*Thomas Patrick Gannon, J.D., Senior Counsel
*Christopher Paul Harvey, Radiation Safety Program Manager
*Benjamin Hunter, Associate Vice President, Public Safety
+Individual, M.D., Interventional Radiologist/Authorized User
*Tim David Kleyn, Assistant Radiation Safety Officer
*Kathryn Manteuffel, University Director, Environmental Health and Safety
#*T. Michael Martin, Ph.D., CHP, DABHP, Radiation Safety Officer
Beau Middaugh, Ph.D., Director, Environmental Health and Safety

*Mark Payne, M.D., Chair RRSC & RDRC
#*Rachel Schmidt, M.S., Assistant Radiation Safety Officer

+The identity of the individual for whom the radiation exposure information has been discussed has not been included in this report to protect his personal privacy.

#Attended the on-site exit meeting on October 20, 2020
*Attended final exit videoconference on April 18, 2022
Representatives of BTG International Canada Inc. contacted by videoconference on April 21, 2021.

Sean Chapel, Nuclear Compliance and Logistics Manager
Scott McGhee, Global Radiation Safety Officer
Steve Muldonn, Quality Assurance Lead
Wayne Mullett, Global Director, Supply Chain & Development
Renee Sayegh, Technical Specialist

INSPECTION PROCEDURES USED

IP 87103, “Inspection of Material Licensees Involved in an Incident or Bankruptcy Filing”
IP 87134, “Medical Broad Scope Programs”

FACTUAL SUMMARY OF
OFFICE OF INVESTIGATIONS REPORT 3-2021-002

On November 12, 2020, the U.S. Nuclear Regulatory Commission (NRC), Office of Investigations (OI), initiated an investigation to determine, in part, whether two interventional radiologists working for Indiana University- IUPUI/IU Medical Center Campus (IUPUI, the licensee) in Indianapolis, Indiana, willfully failed to wear dosimetry assigned by IUPUI. The investigation was completed on November 10, 2021.

The OI investigation showed that both radiologists conducted yttrium-90 (Y-90) administrations (licensed activities) and x-ray fluoroscopy procedures (non-licensed activities) at IUPUI. As radiologists working at IUPUI, their dosimetry consisted of whole body and ring dosimeters assigned by IUPUI. Based on the investigator's interviews with IUPUI radiation safety staff, new dosimetry badges are distributed and collected monthly for forwarding to a third party, Landauer Incorporated, for processing. Only high doses were flagged by the vendor. If a badge was marked as unused or missing, IUPUI would send a survey asking the respective badge wearer about their exposures in the past month.

During their OI interviews, both radiologists identified that they knew wearing their dosimetry was a requirement of both the NRC and IUPUI. Further, they identified that they knew at the time that their respective decisions to not wear dosimetry would place IUPUI in violation of NRC requirements. Both radiologists also acknowledged to the OI investigator that they did not wear their assigned dosimetry and that no one instructed them not to wear it.

Radiologist A has been working with Y-90 and x-ray fluoroscopy since 2012. He described to OI that, at the time, he did not consider that working with radiation at IUPUI without his assigned dosimetry was "that big of a deal" or that there would be "serious" consequences from not wearing the dosimetry. In addition, IUPUI radiation staff identified to OI that Radiologist A was sent surveys asking about his exposures and he did not respond to the IUPUI surveys. IUPUI dosimetry records reflect that Radiologist A did not wear his dosimetry on multiple occasions.

Radiologist B has been working with Y-90 and x-ray fluoroscopy since 2016. He admitted he knew of IUPUI's requirement to wear dosimetry and the existence of NRC dosimetry requirements; however, he did not follow the dosimetry requirement. IUPUI dosimetry records reflect that Radiologist B did not wear his dosimetry on multiple occasions.

Based on the evidence developed during the investigation, it appears that both radiologists violated 10 CFR 30.10(a)(1) by deliberately failing to wear either all or some of the dosimetry assigned to them by IUPUI, and that they did so on multiple occasions during their years of employment at IUPUI. The radiologists' actions appear to have caused IUPUI to be in violation of 10 CFR 20.1502(a)(1).